

# WebReport: A World Wide Web Based Clinical Multimedia Reporting System

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*This paper describes WebReport™, a World Wide Web (WWW) client for the Image Engine multimedia clinical information system under development at the University of Pittsburgh. WebReport uses advanced HTML features such as frames, forms, tables and in-line JPEG image display to provide an easy to use system for retrieving and viewing diagnostic images and reports generated by clinical procedures such as gastrointestinal endoscopy, radiology and surgical pathology. WebReport implements a number of WWW client-side features, such as HTML forms data entry verification and makes extensive use of the JavaScript programming language. The WebReport system uses a number of approaches for ensuring the confidentiality and security of patient data transmitted over the InterNet.*

## INTRODUCTION

The World Wide Web (WWW) has many potential advantages as a medium for the distribution of biomedical information<sup>1</sup>. It provides an inexpensive, cross platform, client-server technology for delivering multimedia data over the InterNet. WWW client software is widely available on all of the major computing platforms and often comes pre-installed on many new desktop computers. Connecting to the InterNet is becoming increasingly affordable in many urban centers in the U.S. This widespread availability, ease of use, sophisticated multimedia support and user acceptance makes the WWW an attractive low-cost solution to the problem of providing access to clinical information via the InterNet. A number of Medical Informatics research groups are currently exploring strategies for accessing the electronic patient record via the WWW<sup>2,3,4,5</sup>.

Many diagnostic procedures that produce clinical images are performed and reported on by medical specialists who are not the patient's primary physician. This is particularly the case in managed care models where each patient has a primary care physician who coordinates his/her care with the help of consulting specialists. Often the primary physician's practice location is remote from the site where clinical procedures are performed. Procedure

reports are usually sent to the referring physician via paper mail. The referring physician and the patient rarely see any associated images such as those produced by gastrointestinal endoscopy or radiology procedures.

Given that an increasing number of physicians have WWW-capable desktop computers at their practice location we have been exploring how one might take advantage of this technology to provide referring physicians with access to clinical procedure reports and associated diagnostic images as part of our National Library of Medicine (NLM) funded High Performance Computing and Communications (HPCC) "Image Engine" project at the University of Pittsburgh Medical Center.

## THE IMAGE ENGINE PROJECT

The Image Engine project<sup>6</sup> is developing a low-cost, client-server, multimedia clinical information system that uses agent-based technology to integrate clinical images with associated textual reports stored in the Medical ARchival System<sup>7</sup> (MARS) electronic medical record at the University of Pittsburgh Medical Center. Image Engine also uses software agents to retrieve information from InterNet-based servers such as NLM's Unified Medical Language System (UMLS) Knowledge Sources Server<sup>8</sup> and the SAPPHIRE<sup>9</sup> document indexing server developed at Oregon Health Sciences University.

One of the goals of the Image Engine research project is to prototype a system architecture that would support an enterprise-wide, integrated, multimedia view of the patient record. Providing clinicians with secure remote access to diagnostic images and reports via the InterNet will be an important feature of future clinical information systems.

The Image Engine client is a sophisticated, graphical user interface application that currently runs on Apple Computer's Power Macintosh workstations equipped with 21 inch high resolution color monitors, accelerated video display hardware and large amounts of RAM (Random Access Memory).

**Image Engine WEB REPORT**

Search Report Split Image Help

**Patient:**

Last Name: Patient

First Name: Annie

ID:

Date of Birth: 9 - 12 - 53

**Procedure:**

Class: CT Scan

Type: Computerized Axial Tomography of Abdomen

Date: 7 - 24 - 96

Site: Abdomen

**Image Note:**

Contains: Aortic Aneurysm

Clear Form

AND

Add to Query Replace Query Clear Query LOAD THUMBS

**Query:**

((FIELD PATIENT\_LAST\_NAME = 'Patient') AND (FIELD PATIENT\_FIRST\_NAME = 'Annie') AND (FIELD PATIENT\_DOB = '9/12/53') AND (FIELD IMAGE\_CLASS = 'CT Scan') AND (FIELD PROCEDURE\_TYPE = 'Computerized Axial Tomography of Abdomen') AND (FIELD PROCEDURE\_DATE = '7/24/96') AND (FIELD PROCEDURE\_SITE = 'Abdomen') AND (FIELD IMAGE\_NOTE contains 'AORTIC ANEURYSM'))

Submit Search Query

**Figure 1: WebReport Query Editor**

While this workstation configuration is necessary to handle the very high resolution color and gray scale still images, digital video and image-processing capabilities supported by Image Engine, the lack of cross-platform client support and the cost of suitable workstations limits the population of clinical users that the system might serve. A WWW-based Image Engine client would provide a potential solution to the problem of making clinical images and reports available across platforms at relatively low cost.

The Image Engine system currently supports a wide range of clinical data, including diagnostic images generated by radiology, gastrointestinal endoscopy and surgical pathology procedures. In addition, Image Engine supports digitized electrocardiograms (EKG), pulmonary function tests (PFT) and other graphical, paper-based clinical reports. Using agent-based, real-

time queries to MARS, Image Engine also provides access to a wide variety of clinical documents such as diagnostic image reports, lab data, discharge summaries, clinic dictations, operative notes etc. To explore how we might provide more widespread access to both images and clinical reports we are developing a WWW-based Image Engine client, called WebReport™.

## WEBREPORT

WebReport is an addition to the Image Engine system which allows clinicians with WWW clients to retrieve and view multimedia clinical reports via the InterNet. To implement this capability we are developing a special version of the Image Engine client application that supports the National Center for Supercomputing Applications' Common Gateway

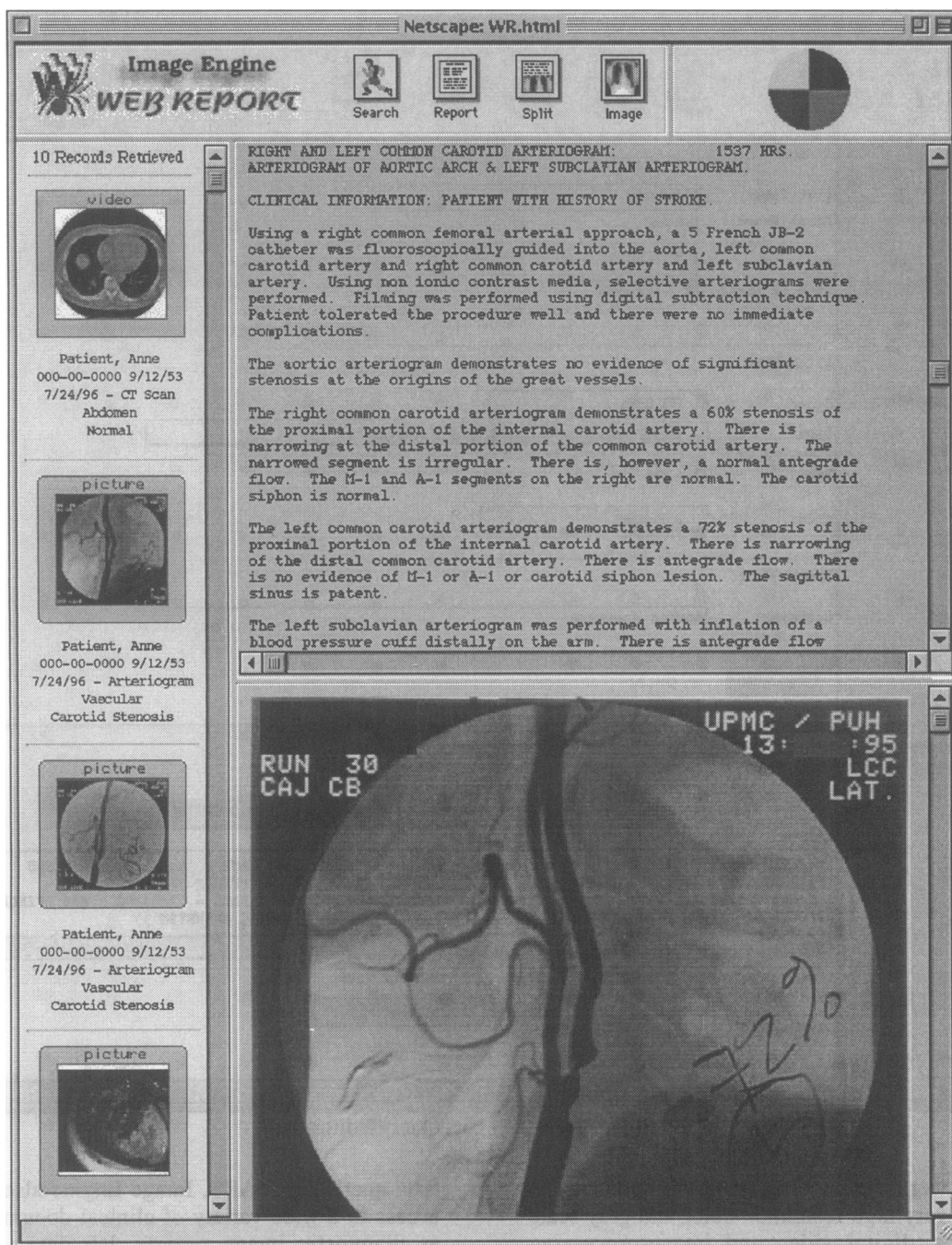


Figure 2. WebReport Browser Screen

Interface (CGI) standard<sup>10</sup>. This CGI-enabled Image Engine client (Image Engine CGI) runs on a central WWW server host and communicates with InterNet-based WebReport clients using the HyperText Transfer Protocol (HTTP)<sup>11</sup>. The role of the Image Engine CGI is to translate HTTP requests sent by remote WebReport clients into valid Image Engine database and image server queries and to format retrieved images and textual data for output to a virtual Hypertext Markup Language (HTML)<sup>12</sup> based display terminal.

## WEBREPORT USER INTERFACE

The Image Engine WebReport WWW Client uses a number of advanced HTML features such as frames, tables, forms and in-line JPEG<sup>13</sup> image display to implement a sophisticated but easy to use human interface. Currently these features are fully supported by a number of WWW browsers, including the widely used NetScape Navigator browser (Netscape Corporation, Mountain View, California). In addition WebReport uses JavaScript<sup>14</sup>, a new cross-platform WWW scripting language, to implement client-side

features such as forms verification, display management and user interface controls. We have pursued a "vending machine" approach to accessing multimedia reports which will hopefully allow the clinical end user to focus on the retrieved data rather than the retrieval process.

Figure 1 shows the WebReport forms-based environment used to formulate Image Engine database queries. Using this JavaScript-mediated forms-based "query by example" interface the clinician can create search queries by combining patient, procedure and image annotation attributes. Complex boolean queries are supported.

Figure 2 shows WebReport's current HTML frame-based environment for viewing retrieved images and procedure reports. The "screen" consists of three active, resizable frames. The leftmost frame displays a scrollable list of image thumbnails representing clinical procedures retrieved by a user query. Each thumbnail is a 100x100 pixel, JPEG compressed, 16 bit color or 8 bit gray scale image representing an image in the Image Engine database. Beneath each thumbnail is a four line label displaying information about the procedure that generated this image, such as patient ID, name, date of birth, procedure type, procedure date and anatomical site. Clicking the mouse on one of the procedure thumbnails sends a request back to the Image Engine CGI to retrieve and forward the associated full size JPEG compressed image and report for the selected encounter. The procedure report is displayed in the frame at top right, while the procedure image(s) are decompressed and displayed in the frame at bottom right. Controls allow the user to easily switch between this view and a full frame view of the image or report.

#### CLIENT-SIDE DATA VALIDATION

One problem with the standard WWW client-server model is that any intelligent processing of client-side data or user input must be carried out on the WWW server which means that even simple verification of user input involves a network round trip between client and server. For example, to verify that data entered into a patient date of birth field in an HTML form is legal, a CGI application running on the server is required to validate the data and return an HTML page warning the user if the data was invalid. This round trip and remote processing detracts from the overall responsiveness of the system and adds to the load on the WWW server.

The advent of the Java<sup>15</sup> and JavaScript programming languages makes it possible to perform many operations, such as data validation and data analysis on the WWW client. WebReport uses JavaScript for a number of client-side processes including "in-line" validation of data entered into

database query forms, display of frame-based information, management of user controls and error reporting. For example, if a WebReport user enters invalid data into an HTML form then client-side JavaScript filters instantly notify the user while still within that HTML form. This significantly reduces the load on the WWW server and more closely resembles the familiar behavior of standard graphical user interface data entry environments.

#### SECURITY AND CONFIDENTIALITY

Protecting the security and confidentiality of clinical information is an important goal of the Image Engine project. Providing access to clinical data via the InterNet makes this issue even more important. WebReport uses a number of methods to protect the confidentiality and integrity of clinical data.

1. When deployed, the WWW Server and clients used by WebReport will use Netscape Corporation's Secure Sockets Layer (SSL) technology<sup>16</sup> to provide data encryption, server authentication, message integrity, and optional client authentication for a TCP/IP connection. Netscape Navigator version 3.0 supports RC4 128-bit encryption SSL to protect data communications across public networks. RC4 128-bit encryption is 288 times harder to decrypt than RC4 40-bit encryption and provides a very high level of data security.

2. The TCP/IP address of each registered WebReport client will be maintained in a secure database (remote from the WWW server host) and access to clinical data is restricted to WWW clients listed in this database. Requests from any other TCP/IP addresses are logged and refused. WebReport will use a number of mechanisms to protect against "IP spoofing", in which the IP address of a trusted client is inserted into IP packets to fool the server into allowing access to an untrusted client.

3. To use Image Engine WebReport from a registered "trusted client" the user must enter a valid user name and password. These names and passwords are stored in a secure database that is remote from the WWW server host and are encrypted prior to transmission from remote client to host. Password characters are echoed as bullets when entered at the client workstation. All login attempts are logged and reviewed.

#### CONCLUSION

At the time of final submission of this paper (July 1996) we have a prototype of WebReport running with all of the main system components functional. We hope to begin limited testing in Fall of 1996. A number of issues remain to be addressed prior to this test phase. These include developing strategies for

maintaining the concept of a "user session" within the WWW's "sessionless" paradigm. We are currently exploring the use "cookies"<sup>17</sup> to implement sessions. A "cookie" is a small piece of information which a WWW server can store on a WWW client and later read back from that client. This is useful for having the browser remember specific information across several pages, keeping track of a users actions and tracking navigational pathways.

A future release of JavaScript will reportedly provide access to Java classes and may allow us to extend WebReport to support many image display and manipulation features currently available in the Macintosh Image Engine Client. Another issue that we plan to explore is how to handle client-side caching of HTML pages and images as this represents a potential security problem and may require some active management of these files by the WebReport client

WebReport may also be useful in telemedicine applications and for using clinical images to support medical education, life long learning and patient instruction. The cross-platform nature of the WWW, its integrated support for multimedia and hypertext and the broad acceptance of the InterNet suggests that a system such as WebReport could find widespread use in patient care, education and research.

Additional information on the Image Engine HPCC Project and WebReport is available at

<http://www.cml.upmc.edu/>

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